RECOMMENDATION SYSTEM USING MATRIX FACTORIZATION

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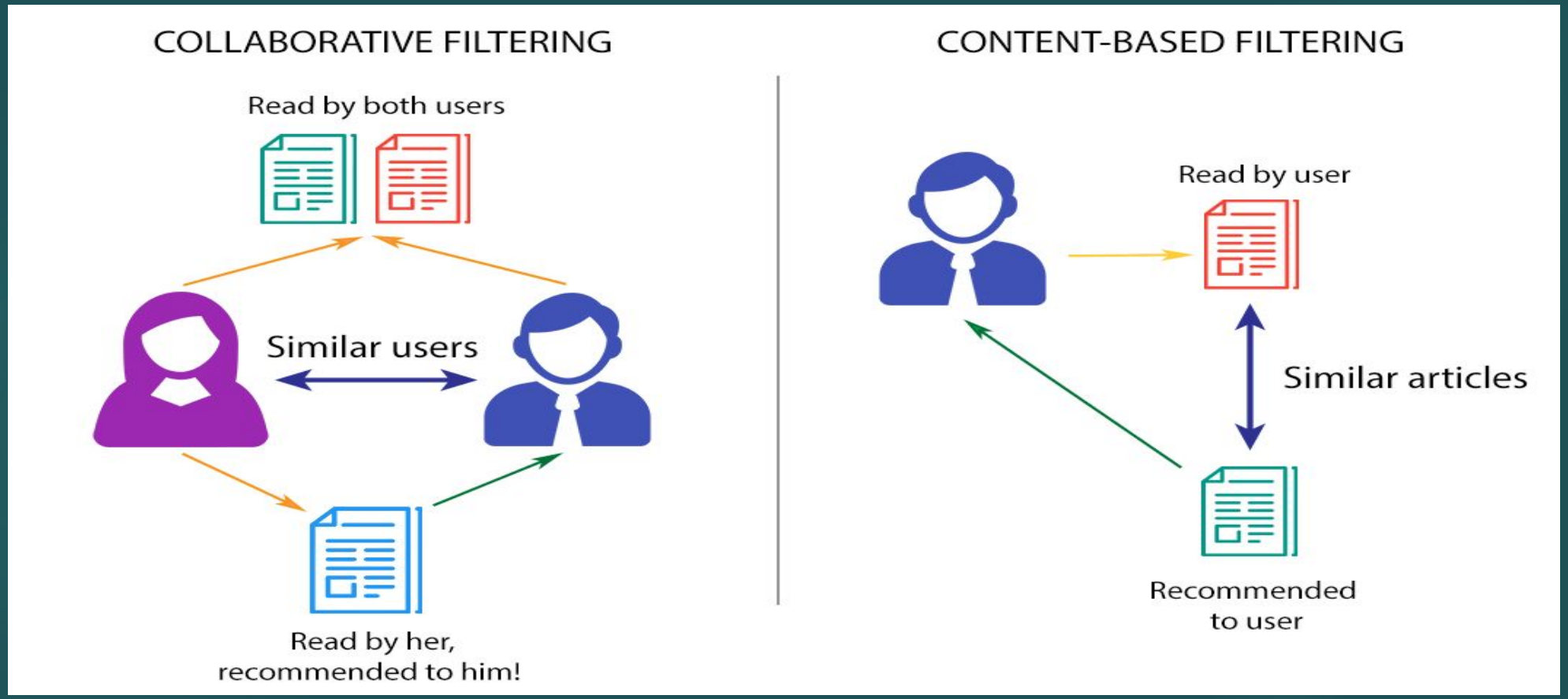
INTRODUCTION TO RECOMMENDER SYSTEMS

- Recommender systems were introduced in the mid-1990s to help people select the most suitable product for them from the plethora of options available with them.
- Recommender systems are utilized in a variety of areas such as Amazon, Netflix, and Youtube.
- The most widely known and used filtering techniques are;
- Collaborative Filtering
- Content-Based Filtering

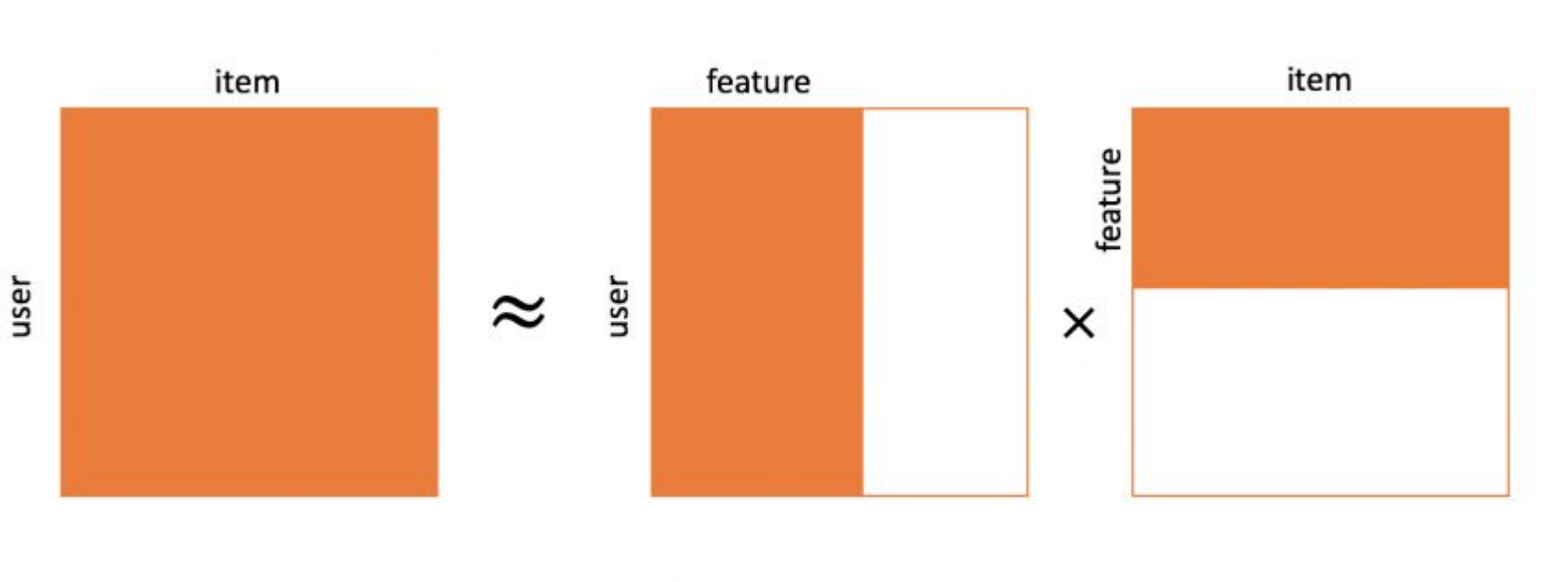
Collaborative vs. Content Based Filtering



Netflix Prize Competition 2006

- The first team that can improve on the Netflix algorithm's RMSE(Root mean squared error) performance by 10 percent or more wins a $1.000.000 prize.
- The contest created within the collaborative filtering field.

What is matrix factorization?



$$\hat{R}_{ui} \sim q_i^T p_u$$

Short example of how matrix factorization works

	F1	F2
U1	1	0
U2	0	1
U3	1	0
U4	1	1

User – Feature matrix

	F1	F2
M1	3	1
M2	1	2
M3	1	4
M4	3	1
M5	1	3

Movie – Feature matrix

	Movie 1	Movie 2	Movie 3	Movie 4	Movie 5
User 1	3	1	1	3	1
User 2	1	2	4	1	3
User 3	3	1	1	3	1
User 4	4	3	5	4	4

Original matrix

The data sets in real-life

	Movie 1	Movie 2	Movie 3	Movie 4	Movie 5
User 1	3		1		1
User 2	1		4	1	
User 3	3	1		3	1
User 4		3		4	4

	F1	F2
U1	0.2	0.5
U2	0.3	0.4
U3	0.7	0.8
U4	0.4	0.5

	F1	F2
M1	1.2	2.4
M2	3.1	1.5
M3	0.3	4.4
M4	2.5	0.4
M5	0.2	1.1

$$e_{ui} = r_{ui} - q_i^T p_u$$

$$Error = (3 - 1.44)^2$$

	Movie 1	Movie 2	Movie 3		ovie 5
User 1	1.44	1.37	2.26	0.7	0.59
User 2	1.32	1.53	1.85	0.91	0.5
User 3	2.76	3.37	3.73	2.07	1.02
User 4	1.68	1.99	2.32	1.2	0.63

=?

	Movie 1	Movie 2	Movie 3	Movie 4	Movie 5
User 1	3		1		1
User 2	1		4	1	
User 3	3	1		3	1
User 4		3		4	4

How to optimize predicted matrix?

User – Feature matrix

	F1	F2
U1	0.2	0.5
U2	0.3	0.4
U3	0.7	0.8
U4	0.4	0.5

Predicted matrix

	Movie 1	Movie 2	Movie 3	Movie 4	Movie 5
User 1	1.44	1.37	2.26	0.7	0.59
User 2	1.32	1.53	1.85	0.91	0.5
User 3	2.76	3.37	3.73	2.07	1.02
User 4	1.68	1.99	2.32	1.2	0.63

Movie – Feature matrix

	F1	F2
M1	1.2	2.4
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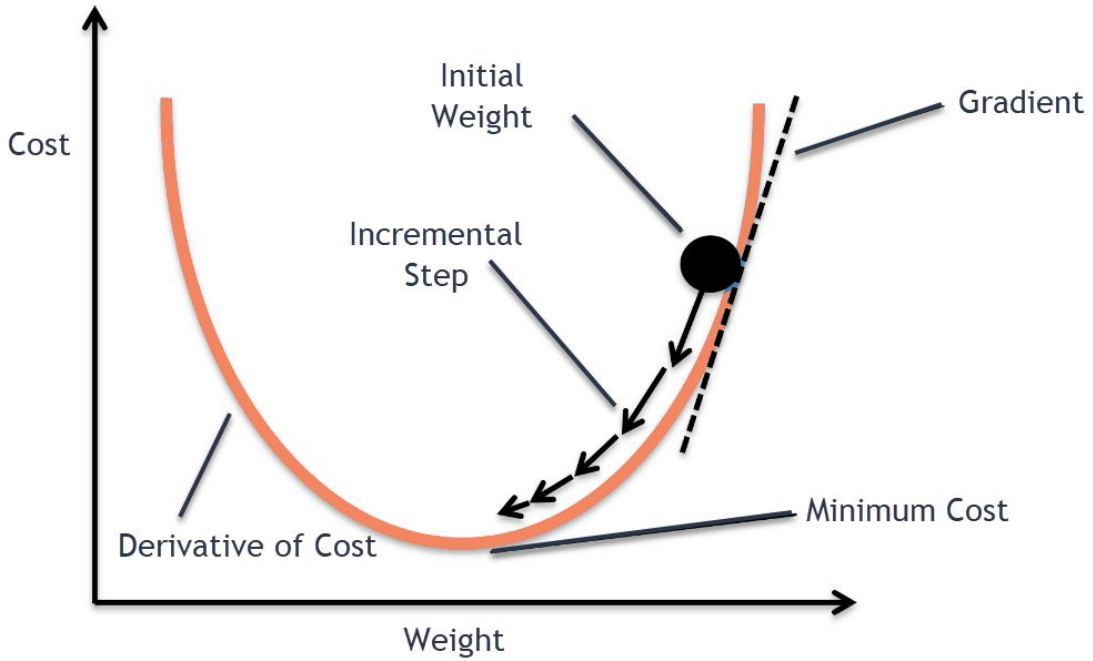
M3	0.3	4.4
M4	2.5	0.4
M5	0.2	1.1



Stochastic Gradient Descent

What is Stochastic Gradient Descent?

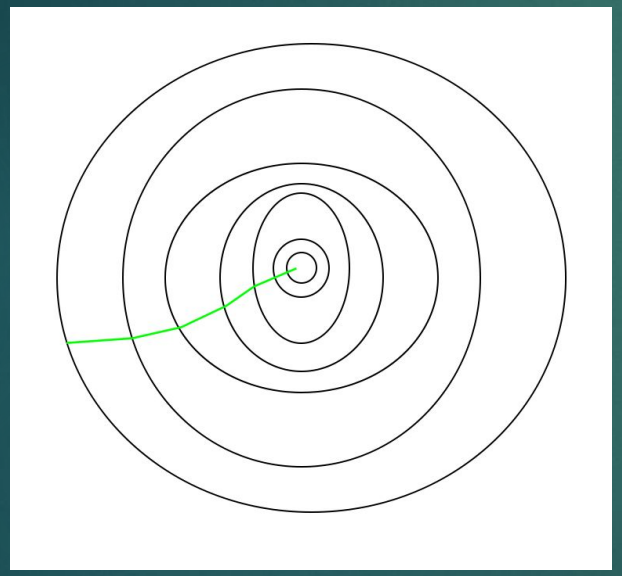
- The word '*stochastic*' means a system or a process that is linked with a random probability.

- In Stochastic Gradient Descent, a few samples are selected randomly instead of the whole data set for each iteration.

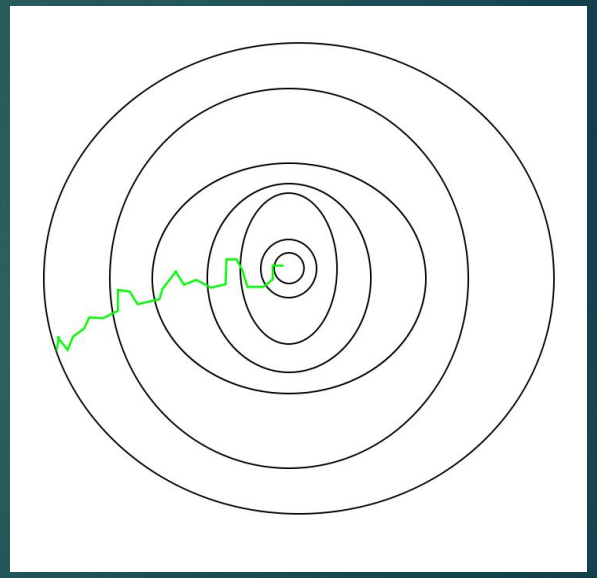
$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (Predicted_i - Actual_i)^2}{N}}$$

- The matrix factorization of user and item matrices can be generated when the math cost function RMSE is minimized through matrix factorization. Stochastic gradient descent is a method to minimize the cost function.

Graident Descent
vs.
Stochastic Gradient Descent

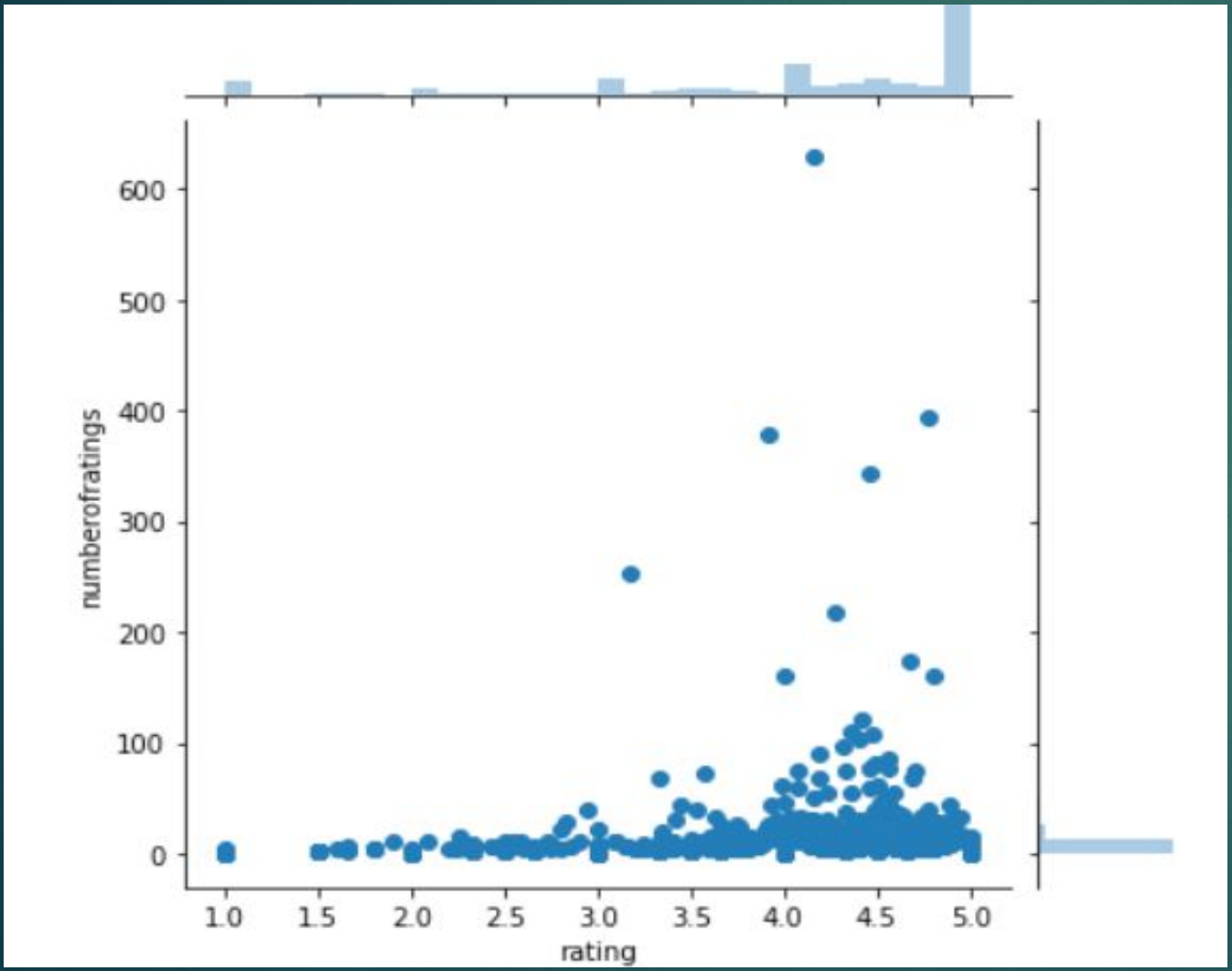


Gradient Descent



Stochastic Gradient Descent

Analyzing Amazon's data set



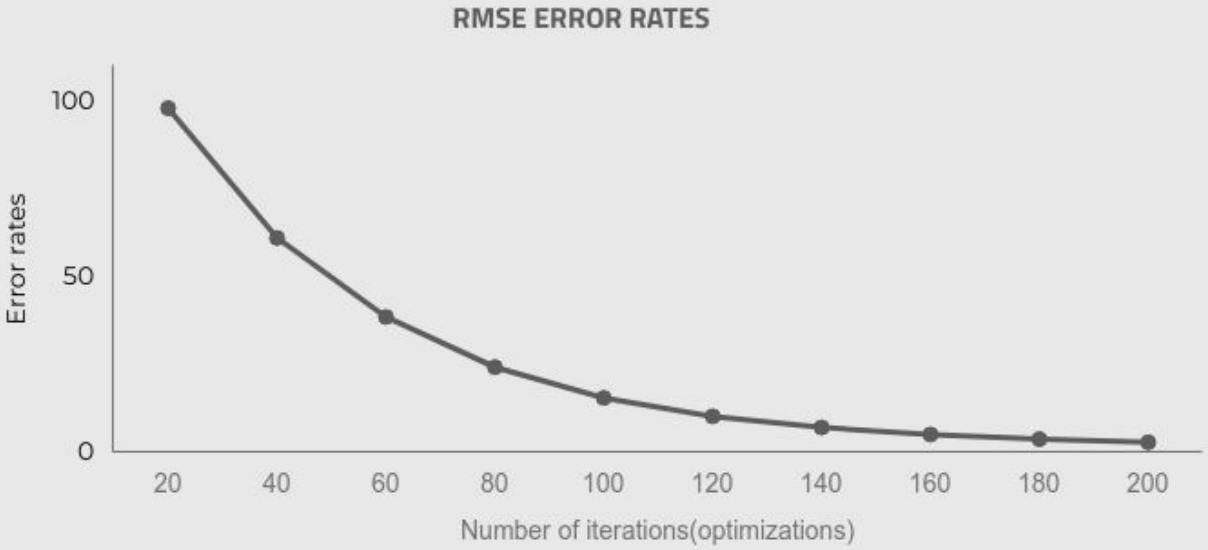
product_id	rating	numberofratings
B00014CZP8	4.158730	630
B00014JNI0	4.770992	393
B00014DJL2	3.923280	378
B0000DID5R	4.466472	343
B00012182G	3.169960	253
616719923X	4.275229	218
B00006IUTN	4.672414	174
B0000W0GQQ	4.801242	161
B0000V8IOE	4.000000	160
B0000531B7	4.418033	122

Analyzing Amazon's data set

product_id user_id	0657745316	0700026444	14037
A021874321O48MHLE22YG	5.0	NaN	
A025365536J4VIIEA7QWY	NaN	NaN	
A03097441ZJL0DBCA4RHL	NaN	NaN	
A03146861HWONIOQQ8SDR	NaN	NaN	
A03590772XZ86W3FKBCO1	NaN	NaN	

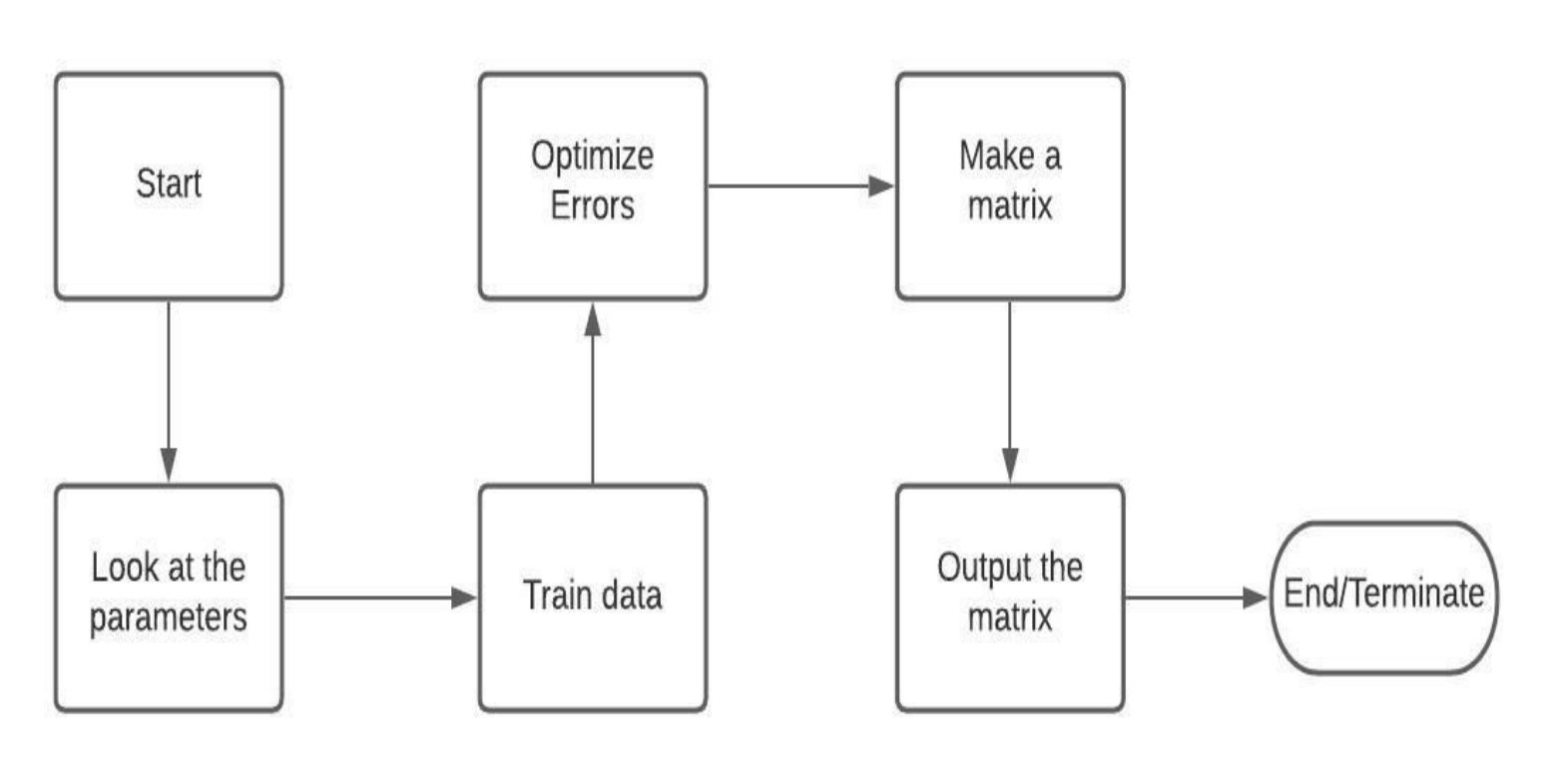
Amazon's Data Set

Books	5-core (8,898,041 reviews)	ratings only (22,507,155 ratings)
Electronics	5-core (1,689,188 reviews)	ratings only (7,824,482 ratings)
Movies and TV	5-core (1,697,533 reviews)	ratings only (4,607,047 ratings)
CDs and Vinyl	5-core (1,097,592 reviews)	ratings only (3,749,004 ratings)
Clothing, Shoes and Jewelry	5-core (278,677 reviews)	ratings only (5,748,920 ratings)
Home and Kitchen	5-core (551,682 reviews)	ratings only (4,253,926 ratings)
Kindle Store	5-core (982,619 reviews)	ratings only (3,205,467 ratings)
Sports and Outdoors	5-core (296,337 reviews)	ratings only (3,268,695 ratings)
Cell Phones and Accessories	5-core (194,439 reviews)	ratings only (3,447,249 ratings)
Health and Personal Care	5-core (346,355 reviews)	ratings only (2,982,326 ratings)
Toys and Games	5-core (167,597 reviews)	ratings only (2,252,771 ratings)
Video Games	5-core (231,780 reviews)	ratings only (1,324,753 ratings)
Tools and Home Improvement	5-core (134,476 reviews)	ratings only (1,926,047 ratings)
Beauty	5-core (198,502 reviews)	ratings only (2,023,070 ratings)
Apps for Android	5-core (752,937 reviews)	ratings only (2,638,172 ratings)
Office Products	5-core (53,258 reviews)	ratings only (1,243,186 ratings)
Pet Supplies	5-core (157,836 reviews)	ratings only (1,235,316 ratings)
Automotive	5-core (20,473 reviews)	ratings only (1,373,768 ratings)
Grocery and Gourmet Food	5-core (151,254 reviews)	ratings only (1,297,156 ratings)
Patio, Lawn and Garden	5-core (13,272 reviews)	ratings only (993,490 ratings)
Baby	5-core (160,792 reviews)	ratings only (915,446 ratings)
Digital Music	5-core (64,706 reviews)	ratings only (836,006 ratings)
Musical Instruments	5-core (10,261 reviews)	ratings only (500,176 ratings)
Amazon Instant Video	5-core (37,126 reviews)	ratings only (583,933 ratings)



Training Amazon's open-to-use data sets

Flowchart of data training



Comparing Results

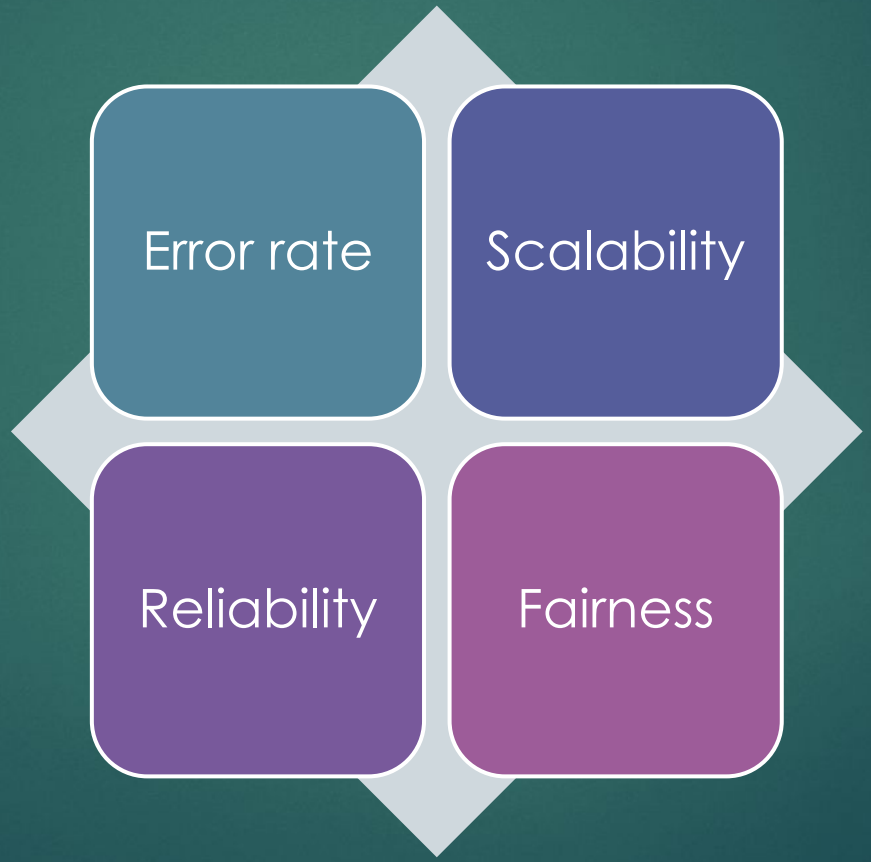
Trained Matrix

	M1	M2	M3	M4	M5
U1	2.99	1.01	1.00	2.96	1.00
U2	1.00	1.88	3.99	1.01	2.82
U3	2.99	1.00	1.00	2.99	1.00
U4	3.94	3.00	4.81	3.99	3.99

Original Matrix

	M1	M2	M3	M4	M5
U1	3	1	1	3	1
U2	1	2	4	1	3
U3	3	1	1	3	1
U4	4	3	5	4	4

Non functional Requirements of Recommender Systems



Advantages and Disadvantages of Matrix Factorization

- Storage
- Fair
- Accurate
- Low error rate

- User dependent
- Cold start
- Stationary structure

Conclusion & Future Work

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- [1] Koren, Yehuda, Robert Bell, and Chris Volinsky. "Matrix factorization techniques for recommender systems." *Computer* 42.8 (2009): 30-37.
- [2] Shani, Guy, and Asela Gunawardana. "Evaluating recommendation systems." *Recommender systems handbook*. Springer, Boston, MA, 2011. 257-297.
- [3] Bennett, James, and Stan Lanning. "The netflix prize." *Proceedings of KDD cup and workshop*. Vol. 2007. 2007.

THANK YOU FOR LISTENING!